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(56) Documents Cited
EP 0538870 A2 US 5708681 A US 5193223 A
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INT CL[6] H03G 3/20 3/30, H04B 7/005
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(54) Abstract Title
Transmit power level control in a mobile telephone

(57) Transmitter power in a mobile telephone is controlled by scaling the digital baseband signal using control lines 29. The scaled baseband signal is converted 6 to an analogue signal and modulated onto an RF carrier. Alternatively, the DAC 6 may be responsive to control signals to effect scaling. The signal output power from the modulator is dependent upon the voltage amplitude of the low frequency input signal. A controlled gain RF amplifier 24 may also be provided. The output power controller 9 is responsive to power command signals 37 from the base station and to detected power output 18,19.

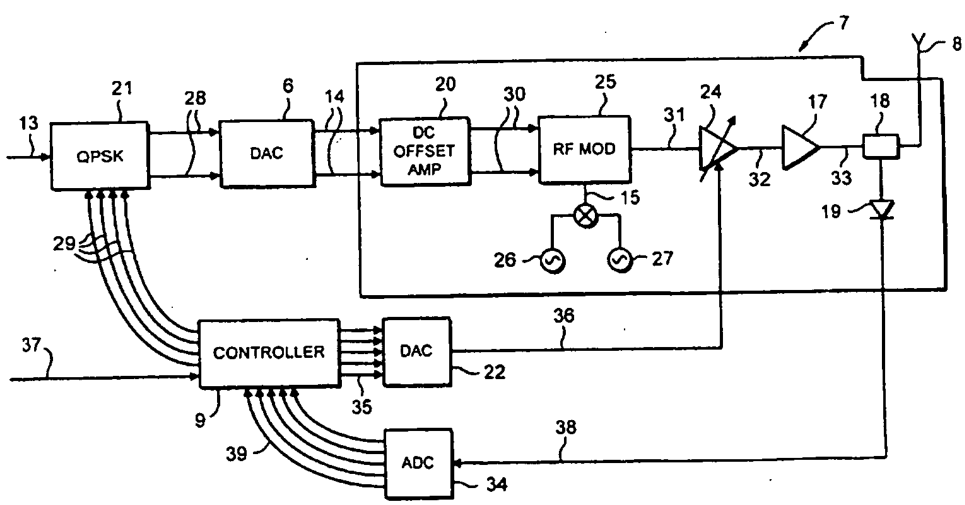

FIG. 2

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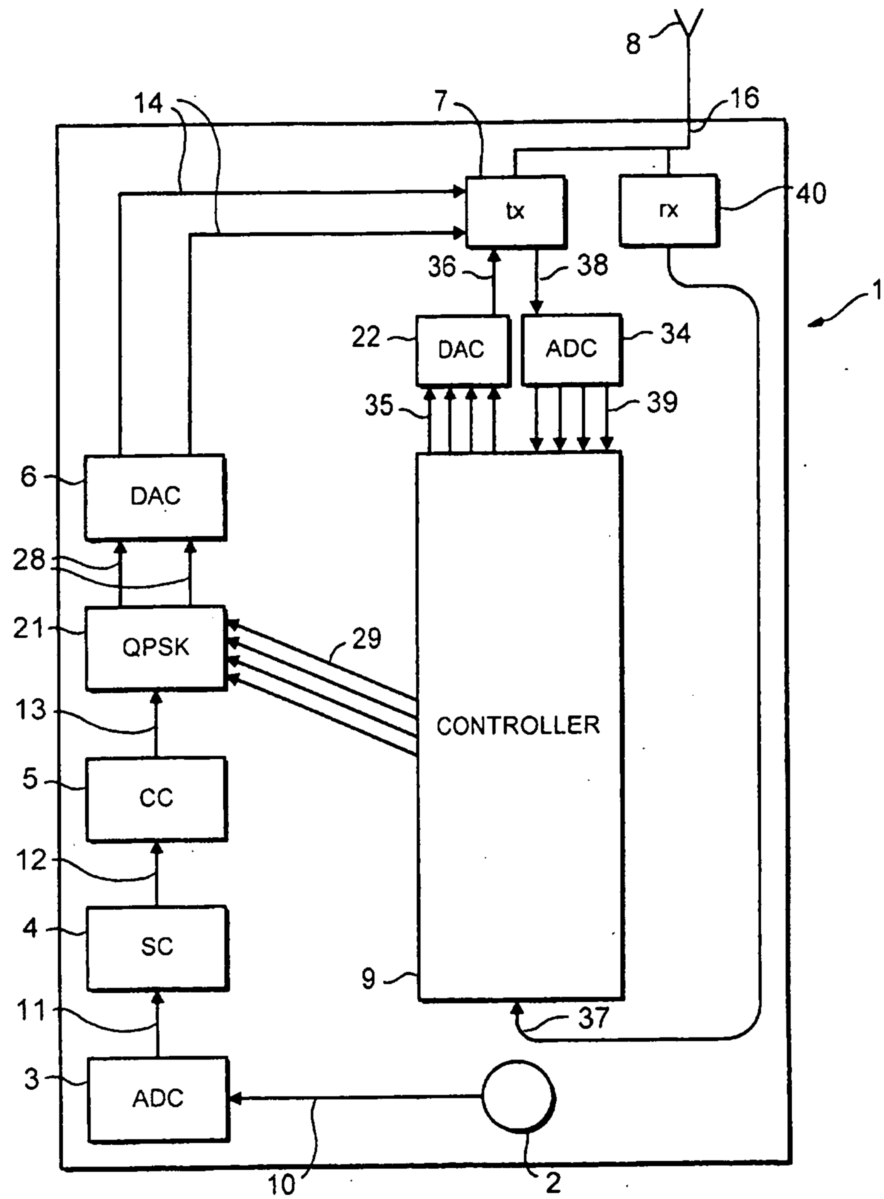
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995



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DAC
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CONTROLLER
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CC
12
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SC
9
11
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ADC
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FIG. 1

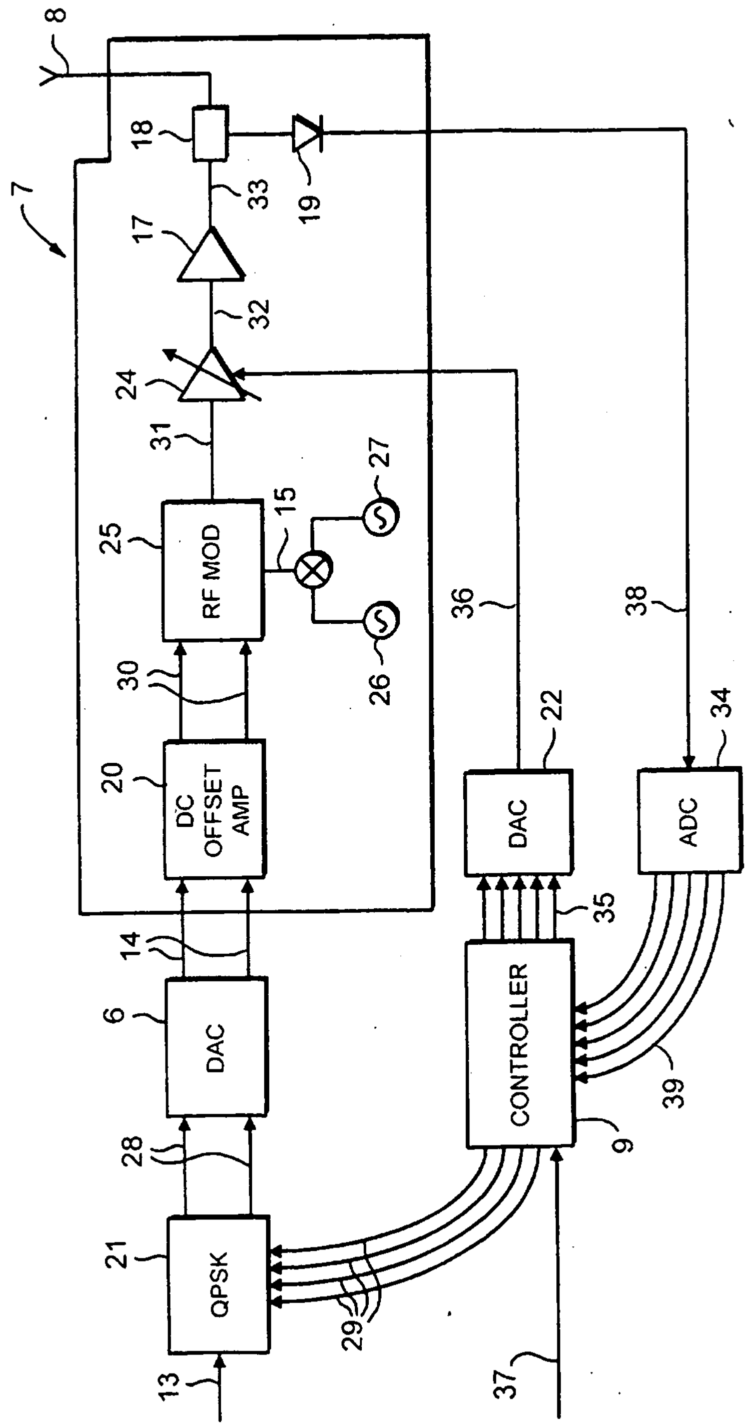
QPSK
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FIG. 2

CONFIRMATION:

FAX SENT: 28 April 1999

PAT 99001 GB

POWER CONTROL CIRCUIT **2349522**

This invention relates to a wireless communication device, and in particular a wireless communication device having a power control circuit for varying the power of a signal.

Portable wireless communication devices, for example radio telephones, typically have a dynamic transmitter power range to compensate, for example, variations in distance from the radio telephone to the receiving antenna of a telecommunication system, propagation conditions or in a spread spectrum system the number of users in a cell. The transmitter power is adaptively controlled, via control messages from a telecommunication system, typically a base station, to the portable wireless communication device. This is to ensure that the power of the received signal at the telecommunication system remains approximately constant and ideally at the minimum necessary power level. This allows a telecommunication system to receive signals from different radio telephones at approximately the same power level while allowing the radiotelephones to minimise current usage.

For radio telephones the appropriate cellular radio telephone standard defines the transmitter power control range and the power control steps. For example, the Global System for Mobile Communication (GSM) standard defines for radio telephones (i.e. class 2 equipment) a minimum power level of 13 dBm's and a maximum power level of 39 dBm's, controllable in steps of 2 dB. Therefore, for GSM a radio telephone is required to have a dynamic power range of at least 26 dB's. The Personal Digital Cellular (PDC) standard defines six power levels between 8 and 28 dBm's, i.e. a dynamic power range of at least 20 dBm's.

However, the radio telephone transmitter must be able to ramp up and down to all specified power levels over a range of temperatures and voltages and overcome component tolerances. Further, to ensure minimal adjacent channel power (ACP) degradation during the ramp up phase of the transmitter a radio telephone will typically ramp up to each of its assigned power levels from a power which is 10 to 20 dB's below its minimum power level. For example, in the case of the PDC standard the lowest power level is +8dBm so typically ramp up will occur from –10dBm.

Consequently, the total required dynamic range of a transmitter may need to be of the order of 60 dB's.

To achieve this dynamic range a transmitter will, typically, vary the power of a RF signal by means of a variable gain amplifier (VGA). The varied RF signal is then provided to a power amplifier for transmission to a base station, via an antenna. However, currently no single VGA is capable of providing a 60 dB dynamic range. Therefore, a transmitter will typically have two VGA's in series. Each VGA providing 30 to 40 dB's of dynamic range thereby providing the transmitter with a dynamic range of between 60 and 80 dBm's. However, each VGA impacts upon the weight, volume, power consumption and cost of the transmitter. It is important, however, that the weight, volume, power consumption and cost of portable wireless communication devices, and in particular radio telephones, are minimised.

In accordance with a first aspect of the present invention there is provided a wireless communication device having a power control circuit for varying the power of a signal, the circuit comprising varying means for varying the voltage amplitude of a baseband data signal between an upper and lower voltage; a modulator for modulating the varied baseband signal with a radio frequency

signal to provide for an output signal which has a signal power dependent upon the voltage amplitude of the varied baseband signal, and detecting means for providing to the varying means a detected signal indicative of the power of the output signal, wherein the varying means is arranged to compare the detected signal with a reference signal and is responsive to the comparison to vary the voltage amplitude of the baseband signal.

This invention provides the advantage of varying the power of a signal using baseband components, thereby avoiding the need for an additional RF component, for example, a variable gain amplifier. RF components are typically complex devices that are larger, heavier and have greater current consumption than corresponding baseband components. Consequently, the present invention allows transmitters weight, size and current consumption to be minimised.

Preferably the reference signal is selectable. Most preferably the reference signal is derived from a control signal transmitted by a telecommunication system.

During operation of a wireless communication device the varying means, typically, receives power control data from a telecommunication system base station requesting the device to increase or decrease the power of the transmitted signal. Consequently, the varying means is able to control the power at which a signal is transmitted by comparing the output signal power with the power control data from the base station.

Preferably the voltage amplitude is varied in accordance with predetermined voltage levels. This allows the signal power to be varied in accordance with the power control steps for communication systems, for example cellular networks.

Preferably the varying means comprises a digital to analogue converter for varying the voltage amplitude of the baseband data signal between the upper and lower voltage.

Preferably the varying means further comprises a controller for comparing the detected signal with the reference signal and in response to the comparison provide a control signal to the digital to analogue converter, wherein the digital to analogue converter is responsive to the control signal for varying the voltage amplitude.

Suitably the power control circuit further comprises a variable gain amplifier for varying the output signal power, wherein the varying means is responsive to the comparison to vary the gain of the variable gain amplifier.

Typically a variable gain amplifier can provide a power control range of up to 40 dB's. Thereby, the dynamic power range of a variable gain amplifier can be increased to over 60 dB's, the range typically required for a radio telephone to operate in a cellular network, without the need for a second variable gain amplifier.

Typically the varying means varies the peak to peak voltage amplitude of the baseband data signal.

In accordance with a second aspect of the present invention there is provided a wireless communication device having a power control circuit for varying the power of a data signal in response to a received power control signal from a telecommunication system, the circuit comprising varying means being responsive to the control signal to vary a baseband data signal voltage amplitude between an upper and lower voltage; and a modulator for

modulating the varied baseband signal with a radio frequency signal to provide for an output signal which has a signal power dependent upon the voltage amplitude of the varied baseband signal.

In accordance with a third aspect of the present invention there is provided a method of varying the power of a data signal in response to a received power control signal from a telecommunication system, the method comprising varying in response to the control signal a baseband data signal voltage amplitude between an upper and lower voltage; and modulating the varied baseband signal with a radio frequency signal to provide for an output signal which has a signal power dependent upon the voltage amplitude of the varied baseband signal.

For a better understanding of the present invention and to understand how the same may be brought into effect reference will now be made, by way of example only, to accompanying drawings, in which:-

Figure 1 is a schematic block diagram of a radio telephone incorporating a power control circuit according to the present invention;

Figure 2 is a schematic block diagram of transmitter incorporating a power control circuit according to the present invention.

Figure 1 shows a radio telephone 1 with a microphone 2, analogue to digital converter 3, a speech coder 4, a channel coder 5, a quadrature phase shift key (QPSK) modulator 21, a digital to analogue converter 6, a transmitter 7, an antenna 8 and a controller 9. In operation the microphone 2 converts an audio signal into a representative low frequency analogue electrical signal 10, otherwise known as a baseband data signal. The analogue signal 10 is passed to the analogue to digital converter 3, which converts the analogue

signal 10 into a digital signal 11. The digital signal 11 is passed to the speech coder 4, which encodes the signal 11 into a lower bit rate digital signal 12 representative of the analogue signal 10. The encoded signal 12 is passed to the channel coder 5, which add error protection bits, otherwise known as channel coding. The error protection bits are used to detect and correct errors that occur during transmission of the signal. The channel coded signal 13 is then passed to the QPSK modulator 21, which converts the digital signal into a real and imaginary digital signal (i.e. I and Q signals). The QPSK modulator 21 outputs the I and Q signals 28 as a series of eight bit words. The eight bit words corresponding to the magnitude of the respective I and Q signal 28. The QPSK modulator 21 is responsive to a control signal from controller, typically a DSP or ASIC, via control lines 29 for determining the scaling of the I and Q signals. For example, if a sine wave is being transmitted the magnitude of the I and Q values, and the associated values in the respective eight bit words will vary sinusoidaly between zero and a full amplitude, where all eight bits are set high. The control lines 29 can be arranged so that individual control lines can independently control individual bits of the eight bit words (i.e. having eight control lines to control eight bits) or the control lines can form a binary number which is used to select which bits to set high for the maximum magnitude of the I and Q signals. For example, if all control lines 29 are set low the QPSK modulator 21 sets all eight bits of the respective eight bit word high for the maximum magnitude of the I and Q signals. If the first control line is set high (i.e. a binary value of 1) the QPSK modulator 21 only sets seven bits high for the maximum magnitude of the I and Q signals, thereby halving the magnitude of the I and/or Q signals. If the second control line is set high (i.e. a binary value of 2) the QPSK modulator 21 only sets six bits high for the maximum magnitude of the I and Q signals, so further halving the magnitude of the I and Q signals.

The I and Q signals 28 are then passed to the digital to analogue converter 6, which converts the digital I and Q signals 28 into respective low frequency analogue signals 14. When the QPSK modulator 21 has set all eight bits high for the I and/or Q signal the digital to analogue converter 6 is arranged to output a 300mV low frequency analogue signal for the respective signals, the baseband data being represented in the low frequency signal as I and Q signalling. When the most significant bit (MSB) of the eight bit word output from the QPSK modulator 21 is set low the output voltage of the digital to analogue converter 6 is halved. Consequently, when only seven bits of the eight bit word have been set high the output voltage amplitude of the digital to converter 6 is 150mV. Therefore, the controller 9 can vary the peak to peak voltage of the low frequency analogue signal between a range of 300mV, when all eight bits are set high, and 2.34mV when only one bit has been set high.

In an alternative embodiment the digital to analogue converter 6 can be made responsive to control signals from controller 9 for determining the scaling and thereby determining the voltage amplitude of the low frequency signal.

The analogue signals 14 output from digital to analogue converter 6 are passed to the transmitter 7.

The transmitter 7, as shown in figure 2, comprises a power amplifier 17, an output coupler 18, a RF detector 19, a DC offset amplifier 20, a variable gain amplifier 24 and a RF modulator 25 with two oscillating sources 26, 27,

The low frequency analogue signals 14 output from digital to analogue converter 6 are passed to DC offset amplifier 20, which imparts a DC offset to each I and Q signal. The DC offset value is selected to avoid grounding and clipping of the signals. For example, to maximise the operational voltage

range for a radio telephone operating from a 2.7V supply the DC offset should be 1.35V.

DC offset I and Q signals 30 are output from the DC offset amplifier 20 and fed to RF modulator 25, which modulates the signal with a RF signal 15 generated by oscillators 26, 27. The oscillation frequencies of oscillators 26 and 27 are chosen so that the sum of the oscillation frequencies of oscillators 26, 27 corresponds to the required transmission frequency of the signal. Two oscillators are chosen in preference to a single oscillator operating at the RF carrier frequency to minimise interference from the power amplifier to the oscillators.

The signal output power from the modulator 25 is dependent upon the voltage amplitude of the low frequency input signal. Therefore, by varying the voltage amplitude of the low frequency input signal the signal power output from the modulator is varied. For example, when the peak to peak voltage of the input low frequency analogue signal 33 is 300mV's, i.e. when all eight bits have been set high by the QPSK modulator 21, the modulator 25 provides an output signal power of –10dBm's. When only seven bits are set high, i.e. the peak to peak voltage is halved, the output power of modulator 25 is reduced by 6dB's, i.e. to –16dBm's.

For a QPSK modulator which uses an eight bit word to represent the magnitude of the I and Q signals to avoid the introduction of excess noise and distortion to the data signal typically only two bits will typically be used to vary the voltage of the low frequency analogue signal. That is to say, the variation in voltage amplitude of the baseband signal will normally provide a dynamic range of 12 dB's. Therefore, preferably, one variable gain amplifier will be used to meet the dynamic power requirements of the appropriate cellular specification. However, a QPSK modulator which represents the magnitude of

the I and Q signals with a different number of bits can be used. For example, a 10 bit QPSK modulator can be used, which allows up to 3 bits to vary the voltage amplitude of the low frequency analogue signal while avoiding excess noise and distortion to the data signal.

The preferred type of modulation technique is direct modulation. Direct modulation, i.e. low frequency analogue signals are directly modulated onto a RF carrier, is typically chosen as variations in power of the input RF signal have minimum variations in output signal power, i.e. the output signal power is solely dependent upon the voltage of the low frequency analogue signal. However, indirect modulation, i.e. low frequency analogue signals are initially modulated with an intermediate RF frequency before being shifted to the RF carrier frequency at a later stage in the transmitter, can be used.

A modulated signal 31 is output from the RF modulator 25 and passed to variable gain amplifier 24, which can vary the gain by, typically, up to 45 to 50dB under the control of the controller 9.

The variable gain amplifier 24 further increases the dynamic power range of the power control circuit. The controller 9 controls the power amplification of the variable gain amplifier 24 via control lines 35 and 36 and digital to analogue converter 22 which is well known to a person skilled in the art. Typically, the dynamic power range of the variable gain amplifier 24 will be of the order of 45 to 50dB's.

A RF signal 32 is output from the variable gain amplifier 24 to the power amplifier 17 for transmission to a telecommunication system, typically a base station (not shown), via antenna 8.

The RF detector 19, which is coupled to the signal output line 33 by output coupler 18, provides a signal to the controller 9 via analogue to digital converter 34. With the analogue to digital converter 34 converting an analogue signal 38 into a digital signal 39 suitable for processing by controller 9 where the analogue signal 38, and corresponding digital signal 39, represents the power of the signal output from power amplifier 17.

The controller 9 controls the operation of the individual radio telephone elements.

A base station (not shown) measures the power of the received signal and determines whether the received signal is within the required range specified by the appropriate cellular network standard. If the signal power needs to be varied the base station transmits a power control messages to the radio telephone requesting that the power control level of the radio telephone be varied.

The power control message transmitted by the base station is received by the radiotelephone, via receiver 40, and a power control signal 37 is provided to the controller. The controller 9 compares the power control information with a reference signal. The reference signal may, for example, be the current signal power transmitted by the radiotelephone and if the reference signal is different to the required signal power the controller 9 will vary the output signal power accordingly. Alternatively, the power control message may indicate a variation in signal power by reference to the existing signal power, i.e. the power control messages indicate an increase or decrease in signal power. If necessary, the controller 9 adjusts the output signal power by varying the voltage amplitude of the baseband data signal as described above

Therefore, the dynamic range provided by the power control circuit will be of the order of 57 to 62dB's. That is to say, typically 12dB's will be provided by varying the voltage amplitude of the low frequency analogue signal and 45 to 50dB's will be provided by the variable gain amplifier 24.

The present invention may include any novel feature or combination of features disclosed herein either explicitly or implicitly or any generalisation thereof irrespective of whether or not it relates to the presently claimed invention or mitigates any or all of the problems addressed. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention. For example, it will be appreciated that other baseband components could be used to vary the voltage amplitude of the baseband signal.

CLAIMS

1. A wireless communication device having a power control circuit for varying the power of a signal, the circuit comprising:

varying means for varying the voltage amplitude of a baseband data signal between an upper and lower voltage; a modulator for modulating the varied baseband signal with a radio frequency signal to provide for an output signal which has a signal power dependent upon the voltage amplitude of the varied baseband signal, and detecting means for providing to the varying means a detected signal indicative of the power of the output signal, wherein the varying means is arranged to compare the detected signal with a reference signal and is responsive to the comparison to vary the voltage amplitude of the baseband signal.

2. A power control circuit according to claim 1, wherein the reference signal is selectable.

3. A power control circuit according to claim 1 or 2, wherein the reference signal is derived from a control signal transmitted by a telecommunication system.

4. A power control circuit according to claim 1, wherein the voltage amplitude is varied in accordance with predetermined voltage levels.

5. A power control circuit according to any preceding claim, wherein the varying means comprises a digital to analogue converter for varying the voltage amplitude of the baseband data signal between the upper and lower voltage.

6. A power control circuit according to claim 5, wherein the varying means further comprises a controller for comparing the detected signal with the reference signal and in response to the comparison provide a control signal to the digital to analogue converter, wherein the digital to analogue converter is responsive to the control signal for varying the voltage amplitude.

7. A power control circuit according to any of the preceding claims, further comprising a variable gain amplifier for varying the output signal power, wherein the varying means is responsive to the comparison to vary the gain of the variable gain amplifier.

8. A power control circuit according to any of the preceding claims, wherein the varying means varies the peak to peak voltage amplitude of the baseband data signal.

9. A power control circuit according to any of the preceding claims, wherein the RF signal is an intermediate RF signal.

10. A radio telephone having a power control circuit according to any of claims 1 to 9.

11. A wireless communication device transmitter having a power control circuit for varying the power of a data signal in response to a received power control signal from a telecommunication system, the circuit comprising:

varying means being responsive to the control signal to vary a baseband data signal voltage amplitude between an upper and lower voltage; and a modulator for modulating the varied baseband signal

with a radio frequency signal to provide for an output signal which has a signal power dependent upon the voltage amplitude of the varied baseband signal.

12. A power control circuit substantially as hereinbefore described with reference to the accompanying drawings, and/or as shown therein.

13. A method of varying the power of a data signal in response to a received power control signal from a telecommunication system, the method comprising:

varying in response to the control signal a baseband data signal voltage amplitude between an upper and lower voltage; and modulating the varied baseband signal with a radio frequency signal to provide for an output signal which has a signal power dependent upon the voltage amplitude of the varied baseband signal.

14. A method of varying the power of a data signal substantially as hereinbefore described with reference to the accompanying drawings, and/or as shown therein.

The Patent Office

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Application No: GB 9909716.4
Claims searched: 1-14

Examiner: K. Sylvan
Date of search: 2 August 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H3G (GPBS,GPXX,GCX)

Int Cl (Ed.6): H03G (3/20,3/30) H04B (7/005)

Other: Online: EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP0538870 A2	NEC. See column 1 lines 58-60 and figure 2.	11,13
X,Y	US5708681	Bell Communications Research. See column 1 lines 58-60 and figure 2.	X: 11,13 Y: 3
X,Y	US5193223	Motorola. See figure 5 and column 7 lines 35-46.	X:1-2, 4,7-9 Y: 3,5,6
Y	US5021753	Motorola. See 100 and 200 in figure 1.	5,6

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		